UNCLASSIFIED

462948

DEFENSE DOCUMENTATION CENTER

FOR

SCIENTIFIC AND TECHNICAL INFORMATION

CAMERON STATION ALEXANDRIA, VIRGINIA



UNCLASSIFIED

DISCLAIMER NOTICE

THIS DOCUMENT IS BEST QUALITY PRACTICABLE. THE COPY FURNISHED TO DTIC CONTAINED A SIGNIFICANT NUMBER OF PAGES WHICH DO NOT REPRODUCE LEGIBLY.

NOTICE: When government or other drawings, specifications or other data are used for any purpose other than in connection with a definitely related government procurement operation, the U. S. Government thereby incurs no responsibility, nor any obligation whatsoever; and the fact that the Government may have formulated, furnished, or in any way supplied the said drawings, specifications, or other data is not to be regarded by implication or otherwise as in any manner licensing the holder or any other person or corporation, or conveying any rights or permission to manufacture, use or sell any patented invention that may in any way be related thereto.

Copy No. O9

46204

Ammonium Perchlorate

Prepared by: Departments of Chemistry and

Chemical Engineering

Auburn University

Mess, Ner

For the Period: 1 Oct 2564 -1 Jan 5 265

20

Contract 10. DA-01-009-0RD-1023(Z). Part 1

Birmingham Procurement District,

U. S. Army.

MAY 1 4 1965
DDC-IRA E

46294

<u>Quarterly Progress Report No. 3</u>

Birmingham Ordnance Contract DA-Ol-009-ORD-1023(Z), Part I, entitled "A Study of the Decomposition Mechanism of Ammonium Perchlorate".

For the period: 1 Oct. 1964 - 1 Jan. 1965.

1. During the period of this report oper-efforts continued with the making of differential thermal analysis (DTA) runs at various heating rates on ammonium perchlorate (AP) samples, where the samples were of various particle size, shape and either pure or contained selected additives.

A total of one hundred and eight DTA plots were made either on new specimens or for rechecking values recorded in Quarterly Report No. 2. Certain of these DTA runs were made with the sample under pressure of nitrogen gas to minimize the sublimation tendency of the AP.

2. (The experimental techniques and equipment used were the same as described in our previous report, except that we began mixing very fine glass beads with the AP material. By using a smaller AP sample, the heat changes of the sample reaction do not influence the results as markedly and hence allow the temperature measuring devices to more accurately indicate the true temperature being experienced by the sample.

Glass beads were selected for the diluting of the material since they are non-conductors for electrons and should show no catalytic influence on the AP decomposition. In all cases we mixed the AP and glass beads in a 1:3 weight ratio.

The glass beads were Sign Beads, type 831A, Size B, wide angle and manufactured by Flex-O-Lite Manufacturing Company of St. Louis, Missouri.

Before being used the glase beads were washed with 3 normal hydrochloric acid solution, rinsed with distilled water and oven dried at 105 degrees C.

A DTA run on the glass beads alone vs. the alundum reference indicated that they underwent no changes over the 25 to 450 degrees C. temperature range that could product exo- or endo-thermic peaks on the DTA plot.

3. Some of the results reported in Quarterly Report No. 2 were based upon too few determinations. In order to increase the reliability of the calculations, the following runs were made, consequently, the following data should be added to:

(A). Table IX of Quarterly Report No. 2

Sample No.	Sample Wt.	Peak T(°C)	Rato	$ln(Rate/T_m^2)$
2-29-1	0.1975	248.9	2,11	-11.769
2-29-2	.2011	255.1	4.16	-11,113
2-30-2	.2034	256.8	10.30	-10.213
2-31-3	,2006	254.0	10.13	-10.219
2-32-1	.1 98 9	258.7	9.87	-10.263
2-33-1	.1968	246.2	2.11	-11.760

(B). Table X of Quarterly Report No. 2

Sample No.	Sample Wt.	Peak T(°C)	Rate	$\ln(\text{Rate }/T_{\underline{a}}^2)$
2-31-2	0,2006	311.0	9.63	-10.475
2-32-1	.1969	316.7	9.36	-10.530

(C). Table XI of Quarterly Report No. 2

Sample No.	Sample Wt.	Peak T(°C)	Rate	$ln(Rate/T_m^2)$

2-29-1	0.1975	439.3	2.13	-12,380
2-29-2	.2011	459.9	3.83	-11.851
2-30-2	.2034	462.2	8.64	-11.044
2-31-3	.2006	453.5	10.00	-10.874
2-32-1	1989	458.0	8.15	-11.091
2-33-1	.1968	443.0	2.25	-12.336

(D). Table XII of Quarterly Report No. 2

Sample No.	Sample Wt.	Peak T(°C)	Rat.	ln(Rate/TE)
2-30-1	0.2017	242.4	2.13	-11.737
2-31-1	.2005	2 4 8.9	4.47	-11.021
2-31-2	.2014	267.7	9.87	-10.300

(E). Table XIII of Quarterly Report No. 2

Sample No.	Sample Wt.	Peak T(°C)	Rate	$ln(Rate/T_m^2)$
~~~~~			****	
2-31-2	0.2014	327.1	8.99	-10.601

#### 4. Erratum.

In Table XIII of Quarterly Report No. 2 the peak temperature for sample 2-25-2 should read 304.5 vice 343.0. The remaining terms in this horizontal line should be changed to  OK  = 577.7;  $T_{\rm m}^2 \times 10^{-5} = 3.24$ ; Rate/ $T_{\rm m}^2 \times 10^5 = 1.260$ ;  $1/T_{\rm m} \times 10^3 = 1.732$ ;  $\ln({\rm Rate}/T_{\rm m}^2) = -11.270$ .

6. In order to minimize the tendency of the AP sample to sublime from the hot to the cooler portion of the sample tube, DTA determinations were conducted under a nitrogen atmosphere where the pressure was maintained at 60 mm. of Hg in excess of atmospheric pressure.

The DTA plots showed three peaks. Peak 1 is the endotherm associated with the change in crystal structure. Peak 2 and 4 (we use 4 instead of 3 for designating this peak so as to indicate that is is the same peak so numbered on the DTA plots run against air pressure and shown in Fig. 4 of Quarterly Report No. 2) are the low and high temperature exotherms.

In the following tables are recorded the results of these runs and the last table summarizes the slope of the curves plotted from these data as well as the calculated activation energies.

Table 6-1

Sample No.	Sample Wt.	Peak T(OC)	Rate	licate/Tm
2-40-2	0.2010	247.8	4.47	-11.014
2-41-1	.2014	246.6	2.34	-11.657
2-41-2	.2034	267.7	10.10	-10.274
2-61-1	.1989	244.2	2.10	-11.756
2-62-1	.2006	257.2	9.20	-10.328
2-62-2	.2003	250.5	4.20	-11.087

Table	6-2	

Faterial - Fine AP; Peak No. 2					
Sample Wt.	Peak T(C)	Rate	ln(Rate/Tm)		
0.2010 0.2034 0.1989 0.2006	298.7 330.9 310.1 318.6	4.43 8.80 2.00 9.80	-11.200 -10.620 -12.044 -12.000		
			And the second seco		
Fine AP: Pea	k No. 4				
Sample Wt.	Peak T(°C)	Rate	ln(Rato/TZ)		
0.2010 0.2019 0.2034 0.1989 0.2006 0.2003	443.0 430.2 479.0 420.6 459.8 443.8	3.13 8.40 2.10 11.00	-12.350 -11.11.7 -12.843 -10,796		
Medium AP; P	eak No. 1				
Sample Wt.	Peak T(°C)	Rate	$\ln(\text{Rate}/T_m^2)$		
0.2002 0.2004 0.2015 0.2024 0.2047 0.2005	241,4 245.8 258.7 253.3 252.10 250.5	2.23 4.21 11.70 4.00 2.20 10.00	-11.685 -11.067 -10.094 -11.146 -11.740 -10.200		
	Sample Wt.;  0.2010 0.2034 0.1989 0.2006  Sample Wt.  0.2010 0.2019 0.2034 0.1989 0.2006 0.2003  Medium AP; P Sample Wt.  0.2002 0.2004 0.2015 0.2024 0.2047	Sample Wt., Peak T(°C)  0.2010	O.2010 298.7 4.43 O.2034 330.9 8.30 O.1989 310.1 2.00 O.2006 318.6 9.80  Fine AP; Peak No. 4  Sample Wt. Peak T(°C) Rate  O.2010 443.0 4.37 O.2019 430.2 3.13 O.2034 479.0 8.40 O.1989 420.6 2.10 O.2006 459.8 11.00 O.2003 443.8 4.26  Medium AP; Peak No. 1  Sample Wt. Peak T(°C) Rate  O.2002 241.4 2.23 O.2004 245.8 4.21 O.2015 258.7 11.70 O.2024 253.3 4.00 O.2047 252.10 2.20		

Table 6-5

Interdal - Medium AF, Peak Wo. 3

Sample No.	Sample Wt.	Peak (°C)	Rate	$ln(Rate/T_m^2)$
2-42-2	0.2004	293.0	4.11	-11.264
2-42-3	0.2015	518.0	8.72	-10.599
2-60-3	0.2024	310.1	4.10	-11.526
2-61-2	0.2047	315.2	2.00	-12.061
2-63-1	0.2005	313.0	9.40	-10.506

#### Table 6-6

Material - Medium AP; Peak No. 4

Sample No.	Sample Wt.	Peak T(OC)	Rate	ln(Rato/Tm)
	······································	و 200 مند عبد طور بوق فود بند گرا مدد کال طور بند	94 470 1 <b>89</b> 447 ++ 444 417	स्था पढ़ क्या कर पुर्क तथा स्था तथा है। एक देश हैंगे स्
2-42-1 2-42-2 2-42-3 2-60-3 2-61-2 2-63-1	0.2002 0.2004 0.2015 0.2024 0.2047 0.2005	484.4 441.1 456.8 458.6 439.3 446.8	2.15 3.95 10.48 4.10 2.30 8.70	-10.883 -11.769 -10.386 -11.770 -12.350 -10.395

#### Table 6-7

Material - Coarse AP; Peak No. 1

Sample No.	Sample Wt.	Peak (°C)	Rate	ln(Rat >/T2)
2-44-1	0.2023	248.9	2.20	-11.727
2-45-1	0.2003	263.4	3.95	-11.200
2-45-2	0.2007	254.3	10.50	-10.135
2-59-3	0.2006	250.1	4.30	-11.050
2-60-1	0.2031	248.2	2.20	-11.725
2-60-2	0.2013	254.4	10.50	-10.135

Table 6-8

Material - Coarse AP; Peak No.2

Sample No.	Sample Wt.	Peak T(°C)	Rate	ln(Rate/T2)
र्थके प्रकृतकुर पार्क गाँक गाँक ताक ताक ताक ताक गाँक	gai, etc. (1885) tags (1881) tags (1881) tags (1881) tags (1881) tags (1881) tags	: बाद क्रम चित्र सिंक क्ष्मा क्षमा व्याप क्षमा प्रकार (धर्म क्षमा वर्ग)		. कर क्षण कुर केले भड़ रूप कम कम तह की का एक
2-45-2	0.2007	317.2	9.00	-10.564
2-45-1	0.2003	529.8	4.04	-11.408
2-59-3	0.2006	296.8	4.10	-11.270
2-60-1	0.2031	303.8	2.10	-11.950
2-60-2	0.2013	514.8	8.90	-10.300

## Table 6-9

Material - Coarse AP; Peak No. 4

Sample No.	Sample Wt.	Peak T(°C)	Ra <b>to</b>	ln(Rate/T2)
	<b>湖 京 市 市 田 山 山 田 田 市 下 田 田 田 田 田 田</b> 田 田 田 田	حجة الله المنا بحم هذا حمد حمد حمد الله الله الله الله الله الله الله الل		سه ۱۹۵۰ کې د د د د د د د د د د د د د د د د د د
2-44-1	0.2023	439.3	2.12	-18.585
2-45-2	0.2007	451.2	9.13	-10.969
2-45-1	0.2005	472.7	4.07	ر ١١٠ و١١-
2-59-3	0.2006	458.0	4.10	-11.778
2-60-1	0.2031	435.5	1.90	-11.486
2-60-2	0.2013	147.5	9.20	-1(,641

Summary of fine, medium and coarse AP DTA vo. nitrogen pressure and the computed activation energies.

Sample	Peak No.	Shope	Act. Energy
da tipp only the law one one tipp one two	ly The great death total strips, and all the level death	z 10 ⁻³	(2003./2010)
Fine AP	1	~29 <b>.</b> 7	80 <b>0</b> 0
Fine AP	8	-18.8	<b>2</b> 845
Fine AP	<u>@</u>	- 9.9	3.00.87
Medium AP	*\$ ****	~\$\\\.\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\\	0.3.5 <b>5</b> 8
Medium AP	S	≈ €.5	150 3
Medium AP	4.	-45,0	2* 4±
Coarse AP	3.	<b>-6</b> 8.0	7. 30
Coarse AP	2	-18.5	5 %
Coarse AF	<i>4</i> 3	- 35.0	6 76

^{7.} The minimum size of sample holder that we have took able to construct and employ (pictured as Fig. 3 of luminorly Report No. 2) required approximately 200 mg of somete of AP to adequately cover the thermocouple so that it sould give sensible voltage values of MAP within the limits of amplification of our equipment.

It was felt that the heat liberated by such a large sample in the very short time of reaction was of such magnitude that it tended to make the sample subject to a temperature value not represented by or recorded as block temperature.

To overcome this difficulty it was decided to use a smaller AP sample but to provide the necessary volume of sample to cover the thermocouple adequately by adding an inert diluting material to the AP, namely very fine glass beads.

Unless otherwise noted the sample was made up by mixing 300 mg of glass beads with 100 mg of AP.

In order that the effect of the glass beads on the calculated results of activation energy might be noted, we made determinations on the medium size AP previously reported on in juarterly Report No. 2 and on the No. 4 Huntsville Sample, both versus air and a nitrogen aumosphere at 60 mm of Hg in excess of air pressure, and these results are reported in the following tables. (Note - the measurements on the Huntsville Wo. 4 without glass leads are recorded in paragraph 6 of this report.)

#### Table 7-1

Material	Medium AP. Pe	eak No l, vs.	Air	
Sample No.	Sample Wt.	Peak T(GC)	Rate	In(Pite/Tm)
			~~	gift and also and sure the sale and also are diffe and fine
2-71-1	3/1	241.6	<b>88.8</b>	-11.6801
2-71-2	3/1	245.4	4.47	-11.0041
2-72-2	3/1	250.9	10.51	-10.1711

#### Table 7-2

Material -	Medium AP; Po	eak No. 2; vs	. Air	
Sample No.	Sample Wt.	Peak (°C)	Rate	ln(R te/t2)
8-72-2 2-73-1	3/1 0 <b>.1</b> 995	350.6 321.8	9.438 8.66	-10 807 <b>6</b> -11 7038

Table 7-3

4

Material - Med	ium AP;	Peak No.	4;	vs.	Air
----------------	---------	----------	----	-----	-----

Sample No.	Sample Wt.	Peak (°C)	Rate	ln(Rate/T _p )
2-71-1	3/1	409.4	2.00	-12.3585
2-71-2	3/1	440.0	4.25	-11.6924
2-72-2	3/1	462.3	10.00	-10.9024
2-73-1	0.1995	463.8	2.00	-12.4900

#### Table 7-4

Material - H4; Peak No. 1; vs. Air

Sample No.	Sample Wt.	Peak (°C)	Rate	ln(Rate/Im)
2-64-1	3/1	256.8	2.34	-11.6954
2-64-2	3/1	258.8	4.28	-11.0992
2-67-1	3/1	251.7	10.40	-10.1844

#### Table 7-5

Material - Ha; Peak No. 2; vs. Air

Sample No.	Sample Wt.	Peak T(OC)	Rate	$\ln(\text{Rete}/T_m^2)$
2-64-1	5/1	209.1	2.0S	-11.9514
2-64-2	3/1	330.0	4.18	-11.3742
2-67-1	3/1	323.3	8.67	-10.5904

#### Table 7-6

Material - H4; Peak No. 4; vs. Air

Sample No	. Sample Wt.	Peak (°C)	Rato	ln(Rate/T2)
2-64-1 2-64-2	3/1 3/1	433.6 467.5	2.13 4.32	-12.4951 -11.7518
2-67-1	3/1	470.9	8.47	-11.0875

#### Table 7-7

Material	•	lią;	reak No.	1;	ve.	Matrogen	

Sample No.	Sample Wt.	Peak T(OC)	Rate	ln(Rate/Tm)
2-65-1	5/1	240.2	2.21	-11.8509
2-66-1	3/1	241.0	4.20	-11.9285
2-67-2	3/1	255.6	11.04	-10.0613

# Table 7-8

Material - R4; Peak No. 2; vs. Mitrogen

Sample No.	Sample Wt.	Peak T(°C)	Rato	$ln(Rato/T_m^2)$
2-65-1	3/1	282.5	1.94	-11.9777
2-66-1	3/1	303.3	3.97	-11.8380
2-67-2	3/1	324.9	8.73	-10.8263

# Table 7-9

Material - K4; Peak No. 4; vs. Nitrogen

Sample No.	Sample '.t.	Peak T(CC)	Rate	$ln(Rate/T_m^2)$
		Mary with Mark Mark Aff or . The Mark Mark Anno April 17 a vice	and 400 cm on 400 km in	And then see and then the two two was also was and
2-66-1 2-67-2	3/1 3/1	422.9 475.3		-11.7048 -10.35일
***	10 10 10 Sept 2 1 1 10 10 10 10 10 10 10 10 10 10 10 10	and an expert of Mary 1 se	S. Jacoby.	the tile of the property

to the first of the control of the first of the control of the con

Table 7-10

Summary of activation energies calculated for to

Summary of activation energies calculated for two samples to note effect of using glass beads:

Sample	Atmosphere	Peak No.	-	Act, Engusy
	n giện tại thiệ kiện mà như dòn dữ lào the day bọ mọ c	or the sea of the real file (the the the the the the the the the the	x 30-3	(kcal./mole)
Medium AP	Air	1	-45.8	cs.o
Medium AP	Air	2	-18.45	50.7
Medium AP	Air	4	-15.00	20.8
H4	Air	1	~94.0	185.8
H4	Air	2	<b>~</b> 0.0	17.9
H4	Air	4	-21.6	42.9
H4	SK	1	-25.8	51.3
H4	NS	2	-11.0	21.9
H4	ns	4	- 9.5	18.9

^{9.} In order to determine the influence of such things as particle size, shape of particle and added conditioners upon the activation energies associated with the decomposition of AP, we were furnished the following samples by Mr. Huskins of the AMC Propulsion Laboratory, Redstone Arsenal, Huntsville, Alabama.

These samples will be designated H-1 through H-5 and their specifications are as follows:

H-1: 400 micron, rounded AP, 99.2% minimum AP, conditioned with tricalcium phosphate (TCP), lot no. 4080.

H-2: 45 micron, rounded AP, 99.2% minimum AP, conditioned with TCP, lot no. 1030-194-1.

H-3: 17 micron, ground AP, conditioned with TCP, lot no. 2153.

H-4: 180 micron, unground AP, conditioned with TCP, lot no. 2153.

H-5: 8 micron, ground AP, conditioned with TCP.

H-6: 90 micron, rounded AP, conditioned with TCP, 99.2% minimum AP, lot no. 1075-38-11.

In the following tables are the peak temperatures measured for these samples at different heating rates. All of these samples were run versus air pressure, and without glass beads as a dilutent. A table summarizing the calculated activation energies of these samples concludes this paragraph.

#### Table 8-1

Material - AP H-1; Peak No. 1

Sample No.	Sample Wt.	Peak (°C)	Rate	ln(Rete/Tm)
2-45-3	0.2004	248.6	4,48	-11.015
2-46-1	0.1997	254.9	10.39	-10.1973
2-54-1	0.2033	251.3	2.2	-11.720
2-72-1	0.1943	243.4	2.37	-11.520

Table 8-2

Material -	AP,	H-1;	Peak	No.	$\mathfrak{L}$
------------	-----	------	------	-----	----------------

Sample No.	Sample Wt.	Peak T(°C)	Rete 3m(Nave/ $T_{ m H}^2$ )
2-45-3	0.2004	290.7	1.11 -11.0506
2-46-1	0.1997	305.0	.9.12 -10.002
2-54-1	0.2033	284.9	8.1 -11.0070
2-72-1	0.1943	278.2	1.55 -11.9490

## E-8 eldsT

	•	Material		AP,	H-1;	Peak	No.	4
--	---	----------	--	-----	------	------	-----	---

Sample No.	Sample Wt.	Feak T(C)	Ratio	$In(Reco/R_{T_1}^2)$
******		په هم دي وي در در دي وي در در دي وي دي دي وي دي وي د دي وي		
2-54-1	0.2033	454.8	3.10	12.385
2-45-5	0.2004	445.0	4.50	-7.1.6 <b>4</b> 4
2-46-1	0.1997	440.8	30.38	-10.828

## Table 8-4

Material - AP, H-2; Posk N 1

Sample No.	Sample Wt.	Fesk T(CC)	Rate	$\ln(\mathrm{Rate}/T_{\mathrm{m}}^{3})$
	ين جو	ജെത്തെയ്ത്തെയ്ത്തെയ്ക്ക് എന്നെ കേ 1	و جد جہ جو ورکی میں یہ	
2-46-2	0.2013	241.9	4.47	-10.3912
	2008.0	259.0	9.90	-10.2628
2-46-3 2-56-3	0.2029	245.0	2.20	-11.7120

# Table 8-5

Material - AP, H-2; Peak No. 2

Sample No.	Sample Wt.	Peak T(°C)	Rate	in (list : /V)
2-46-2	0.2013	207.5	6.36	3.1.551
2-48-2	3008,0 3008,0 9208,0	516.9	a .93	20.3003
2-56-3	<b>9.</b> 8089	279.8		.3.2.7077

T	A	b	1	8	8	<u>-6</u>

Material - AP. H-2: Peck No. 4	Material	- AP.	W-2:	Peok	No.	٠,
--------------------------------	----------	-------	------	------	-----	----

Sample No.	Sample Wt.	Pesk T(°C)	Rate	ln(Rate/Ta)	
2-46-2	0.2015	427.4	3.87	-11.7505	
2-48-2 2-56-3	0.2029	<b>44</b> 9.6 429.4	8.77 2.10	-10.9958 -12.5673	

#### Table 8-7

Material - AP, H-3; Peak No. 1

Sample No.	Sample Wt.	Peak T(OC)	Rate	$\ln(\text{liste}/T_{\rm m}^2)$
and the last way was type and that the title one cast t	age was don't like tour this ten ton this tell this ten 1% are wi	d all the second	<b>●</b> #46 h 4 <u>4</u> 5 ** (3 +4	arts you was one one had one had ago ago allo also ago.
2-50-1	0.2002	248.6	4.8	-11.0560
2-50-2	0.2028	247.7	2.2	-137224
2-50-3	0.2002	255.7	10.4	-10.1996

#### Table 8-8

Material - AP, H-3; Feak No. 2

Sample No.	Sample Wt.	Peak T(OC)	Rate	ln ( late/T2)
way trib day	ETH HOP OF ME SEC NEW CTH SEV O'TH SEA CEN ON HOM NOW N'TH NOW CE			
2-50-1	0.2002	299.5	4,3	-11 8800
2-50-2	0.2038	891.0	2.1	-13.9316
2-50-5	0.2002	325.7	9.3	-10.5708

# Table 6-9

Material - AP, H-3; Peak No. 4

Sample No.	Sample Wt.	Peak T(C)	Rato	ln (Rate/Tm)
2-50-1	0.2002	428.8	4.5	-11.5490
2-50-2	0.2028	424.4	2.0	-12.4019
2-50-3	0.2002	445.0	10.69	-10.7639

#### Table 8-10

Material - AP, H-4; Pask No. 1

Sample No.	Sample Wt.	Peak T(CC)	Rate	In(Rate/Tm)
	*************************************	الله فالله الله الله الله الله الله الله	<b>Car thy str. ore</b> was rea un	ر الله ( الله الله الله الله الله الله ال
2-49-2	0.2055	247.8	4.5	-11.0072
2-53-1	0.2010	244.2	2.5	-11.58%
2-56-1	0.2002	264.8	8.9	-10.8883

#### Table 8-11

Material - AP, H-4; Peak No.2

Sample No.	Sample Wt.	Peak T(°C)	Rate	$\ln(\text{Rate}/T_{n}^{2})$
#1 <b>#2 #2 #2</b> #2 #4 #4 #4 #4 #4 #4 #4 #4 #4	100 to	the 1 ⁴⁸ the decision are the fact and and other way was		المراجعة الم
2-49-2 2-53-1 2-56-1	0.2055 0.2010 0.2003	294.9 268.8 319.5	2.1.	-11.2736 -11.5485 -10.5611

#### 

Material - AP , H-4; Peak No. 4

Sample No.	Sample Wt.	Peak T(°G)	Rate	ln (Rete/Tm)
2-49-2	0.2055	646.8	2.10	-31.6825
2-53-1	0.2030	439.5		-32.0954
2-56-1	0.2003	471.5		-30.0279

#### Table 8-13

Material - AP, H-5; Peak No. 1

Sample No.	Sample Wt.	Poak (°C)	Rate	ln(Rate/Ta)
2-54-2	0.2003	251.3	6.5	-11.0663
2-58-1	0.2000	342.8	8.0	-11.7968
2-58-2	0.2003	250.7	9.7	-10.8881

## Table 8-14

Material - AP, H-5; Pack No. 6

Sample No.	Sample Wt.	Poak T(°c)	Rate	$\ln ( ext{Rate}/ extstyle{T}_{ ext{III}}^2)$
2-54-2	0.2003	487.5	4.1	-11.6752
2-58-1	0.2000	403.6	1.9	-18.7896
2-58-2	0.2008	455.1	10.2	-10.8540

#### Table 8-15

Material - AP, M-5; Peak No. 1.

Sample No.	Sample 17%.	PonkP(°C)	Erso	ln (Lavo/P _M )
-con. red, 400 took half first four last right spin som	age gia tru fidig gan dine may sah rine gay gan men yan kii yel	والمها ومعالمها والأمام فياد الأدار كالأرام الماسية		there was the day on me had be the second on year year.
2-56-2	0.000	08 <b>9.0</b> /	4.4	-12.0407
2-58-3	0.2012	845.0	8.8	-22.7221
2-59-1	0.2004	257.6	10.7	-10.1785

#### Table 8-16

Material - AP, H-S; Peak No. 8

Sample No.	Sample Wt.	Peaky(°C)	Date	In(Nato/T2)
2-56-2	0.2000	500.6	0.8	-11.5347
2-58-3	0.2012	205.3	. 2.3	-33.0555
2-59-1	0.2004	346.3	9.0	-5.9.0575

#### Table 8-17

Material - AP, H-6; Foak No. 5

Sample No.	Sample Wt.	Peak T(Cg)	Rate	In(Mate/TZ)
2-56-2	0.2000	405.5 ~	4.2	-1.0.7500
2-53-3	0.2012	434.4	2.4	-1.0.9700
2-59-1	0.2022	405.4	8.6	-1.0.0 <b>347</b>

Table 8-18

Summary of activation energies calculated for samples supplied by Propulsion Laboratory.

*** **** *** ** ** ** ** ** ** ** **	*************************		الله المحافظة المحافظ
Sample	Peak No.	Slope	Act. Enorgy
		x 10 ⁻³	(kcal./mole)
	Dir Nadi stay with the stay tags, with the stay stay stay to the stay with the stay of	the project of the date out and date type quite type, is such about the	
Hl	1	200.7	59 _{.0} 0
Hl	2	-16.6	25.0
Hl	4	-62.0	125.5
H2	1	_20 <b>.2</b>	40.1
H2	ន	- 9.3	30.4
HZ	<b>4</b>	-88.0	57.0
H3	1	<b>-</b> 36 <b>.0</b>	111.2
нз	ខ	-11.0	21.0
н3	4	-57.5	76.5
H4	1	-17.6	55.0
H4	2	- 7.2	14.5
H4	4	-25.6	45.9
H5	1	∽82 <b>.</b> 8	45.3
H5	4	-15.4	30.8
Н6	1 .	-35.0	69.5
H6	2	- 9.1	18.1
H6	4	-30.0	59.5

9. For the purpose of determining the influence of catalytic agents on the activation energies of the AP decomposition,
DTA runs were made wherein a given amount of an added compound was mixed with the AP.

Two materials, finely powdered aluminum oxide and iron (III) oxide, have been studied for their catalytic effect on the AP decomposition reactions.

In all cases 0.10 g of AP was mixed with the glass beads in a 5:1 weight ratio and then 5% by weight of the AP equalled the weight of the added catalytic agent. All of these were physically stirred together for a length of time deemed the stirred together for a length of time deemed the stirred together for a length of time deemed the stirred together for a length of time deemed the stirred together for a length of time deemed the stirred together for a length of time deemed the stirred together for a length of time deemed the stirred together for a length of time deemed the stirred together for a length of time deemed the stirred together for a length of time deemed the stirred together for a length of time deemed the stirred together for a length of time deemed the stirred together for a length of time deemed the stirred together for a length of time deemed the stirred together for a length of time deemed the stirred together for a length of time deemed the stirred together for a length of time deemed the stirred together for a length of time deemed the stirred together for a length of time deemed the stirred together for a length of time deemed the stirred together for a length of time deemed the stirred together for a length of time deemed the stirred together for a length of time deemed the stirred together for a length of time deemed the stirred together for a length of time deemed the stirred together for a length of time deemed the stirred together for a length of time deemed the stirred together for a length of time deemed the stirred together for a length of time deemed the stirred together for a length of time deemed the stirred together for a length of time deemed together

The following tables give the measured values for the DTA runs and the final table summarizes the computed activation energies of the reactions.

Table 9-1

Material - Fine AP, with MegOg; Peak No. 1; vs Air at atmospheric pressure

Sample No.	Peak T(°C)	Rate	ln(Rate/T2)
2-85-1	247.0	2.1	-11.7664
2-85-2	248.9	14.9	- 9.8210
2-84-2	251.3	4.2	-11.0375

Table 9-2

Material - Fine AP, with FegOs; Peak No. 4; vo. air at atmospheric pressure.

Sample No.	Peak (OG)	Rate	$\lim\{I/\log/R_{\Pi}^{2}\}$
100 die 100 to 100 to 100 die 100 die 100 die 110 die 110 die	THE STREET OF TH	عب عيد حدد دين ڏاڻ منڌ جوءِ هي عود هند ميرد بيءِ آهو. اها ۾ اه	of the second control
2-85-1	852.9	2.0	~10.1759
2-85-2	396.2	7. 9	-10.9453
2-84-2	<b>3</b> 39.1.	4.0	~11.5437

#### Table 9-3

Material - Fine AP, with FcgOg; Pcak No. 1; vs. 2 at 60 mm. excess pressure.

Sample No.	Poak T(CC)	Rate	$\ln(\text{Rete/T}_{m}^{2})$
नेप्प क्रिके प्रथम ५४क कृष्टि चर्चा और 21 कर इस्ट व्यक्ति वहर्ग कर्म	4.29 Med 4860 ABT 4880 your gates flows your gast gave your flow your first deliga days first	tion in the tree was take the see that the see a	நார் செய்து வார்க்கு வரும் குறும் இரும் இரும் நார் செய்து வரும் குறும் இருந்து
2-86-1	250,0	12,2	-10.0185
2-91-1	84 <b>8.2</b>	2,8	-11 "050
2-91-2	543.9	4.2	11 1100

#### Table 9-4

Material - Fine AP, with  $Fe_20_3$ ; Poak No. 4; vs.  $N_2$  at 60 mm. excess pressure

Sample No.	Peak (OC)	Rate	$\ln(\text{Rete}/T_{m}^{2})$
64 Sh rei, Sh Sh Sh 45 ga, gp an ap ag	- ma	AND DOCUMENT THE PERSON AND THE PERS	. and the same was with the same of the sa
2-86-1 2-91-1	<b>597.</b> 4 357.8	8.0 2.0	-10 03 <b>06</b> -18 1 <b>70</b> 0
<b>2-91-</b> 2	380.0	3.8	-11.3500
			•

Table 9-5

Material - Medium AP, with FegOg; Foak No. 1;	Material .	Medium AP.	with FegOz;	Poak Mo. 1;	vo. Air
-----------------------------------------------	------------	------------	-------------	-------------	---------

Sample No.	Peak T(OC)	Rate	$n(Rate/T_m^2)$
2-79-1	250.1	13.7	- 9.9042
2-82-3	252.9	4.3	-11.063
2-32-2	250.9	2.2	-11.7167
2-81-1	250.1	2.2	-11.7137

## Table 9-6

Material - Medium AP, with FegO3; Peak No. 4; vs. Air

Sample No.	Peak (CC)	Rato	$\ln(\text{Rate}/T_m^2)$
	. (**	n the ter sag on all one on all or on one	الله الله عليه على الله الله الله على الله الله على الله الله الله الله الله الله الله ال
2-79-1	401.9	0.13	-10.9181
2-82-3	400.0	4.13	-11.6057
2-82-2	372.9	2.13	-18.1857
2-81-1	372.5	2.13	-10.1943

#### Table 9-7

Material - Medium AP, with FegO3; Peak No. 1; vs. Ng at 60 mm. excess pressure.

Sample No.	Foak T(OC)	Rate	ln(Rate/T2)
	· · · · · · · · · · · · · · · · · · ·		
2-81-1 2-83-2 2-83-1	252.5 251.7 251.3	13.50 4.31 2.11	- 9.9286 -11.0655 -11.7780

Table 9-8

Material - Medium AP, with Fe203; Peak No. 4; vs. N2 at 60 mm. excess pressure.

Sample No.	Peak (°C)	Rate	ln(Rate/Tm)
2-81-1 2-83-2	419.1 395.1	8.38 4.13	-10.9540 -11.5911
2-85-1	373.6	2.13	-12.1876

#### Table 9-9

Material - Fine AP, with Algon; Paak No. 1; vs. Air

Sample No.	Feak T(CC)	Rate	ln(Rate/T2)
	***	~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~	
2-79-2	249.7	4.34	-11.0509
2-80-2	252.1	13.80	~ 9.9022
2-81-2	252.5	2.47	-11.6250

#### Table 9-10

Material - Fine AP, with AlgOg; Peak No. 4; vo Air

Sample No.	Peak (°C)	Rate	la(Rate/T2)
2-79-2	<b>596.</b> 3	4.00	-11.6256
2-80-2	418.0	6.00	-10.9973
2-81-2	3 <b>77.</b> 8	2.25	-12.1460

# Table 9-11

Material - Fine AP, with Al₂0₃; Peak No. 1; vs. N₂ at 60 mm. excess pressure.

Sample No.	Peak T(°C)	Rate	$\ln(\text{Rate}/T_m^2)$
	*****	******	* 300
2-76-2 2-76-3 2-80-1	255.6 251.3 253.6	4.10 11.45 2.37	-11.1154 -10.0858 -11.6703

Table 9-12

Material - Fine AP, with  $Al_2O_3$ ; Peak No. 4; vs.  $N_2$  at 60 mm. excess pressure.

Sample No.	Poek (OC)	Rate	ln(Rate/T2)
gay gas and ago only dily gas mits fire they are tags the			الله ينك الله الله الله الله الله الله الله الل
2-78-2	388.7	4.13	-11,5718
2-78-3	419.1	9.75	-10,8028
2-90-1	<b>375.</b> 9	2.00	-12.2547
			•

## Table 9-13

Material - Madium AP, with Algo,; Peak No. 1: vs. Air

Sample No.	Peak T(OC)	Rate	. lr(Rate/T2)
2-76-1	247.8	4.54	-11,0484
2-76-2	251.7	12.70	- 9,9843
2-77-2	248.5	1.97	-11,685

#### Table 9-14

Material - Medium AP, with Al2)3; Peak No. 4; vs. Air

Peak (°C)	Rate	ln(Rate/TZ)
		PB (15) 450 m sp.
404.9	3.88	-11.6926
433.6	10.38	-10.7814
386.1	2,25	-12.1713
	404.9 433.6	404.9 3.88 433.6 10.38

## Table 9-15

Material - Medium AP, with Al₂O₃; Peak No. 1; vs. N₂ at 60 mm. excess pressure.

Sample No.	Peak T(°C)	Rato	$\ln(\text{Rate}/T_{m}^{2})$
2-76-3	252.1	4.34	-11.0598
2-77-1	252.5	13.03	- 0.9621
2-78-1	252.1	2.03	-11.7954

#### Table 9-16

Material - Medium AP, with  $AlgO_3$ ; Peak No. 4;  $vs.\ N_2$  at 60 mm. excess pressure.

Sample No.	Peak (°C)	Rate	$\ln(\text{Rato}/\epsilon_{11}^2)$
	po atta finn das das PPs das PPs que das situ-ent inn qua face de de	. <b>(1) (1) (1) (1) (1) (1) (1) (1) (1) (1) </b>	and the fact the get use that the same and up, by the gift this per
2-76-3	397.0	4.00	-11.0283
2-77-1 2-78-1	435.9 <b>371.</b> 4	2.00 2.13	-11.0484 -18.1316

Table 9-17
Summary of activation energies calculated for AP with added catalysts.

Sampl	 Le	Atmosphere	Peak	Slope	Act. Energy
			***		(kcal./mole)
Fine	AP/Te20	Air	1	-90.0	178.8
	**	Air	<u>a</u>	-11.2	22.05
•	*	N ₂	1	- 260	517.3
	Ħ	N _S	. 4	-15.1	30.0
Medi	um Al'/	Air	. 1	- 7.7	15.3
Fe	2 <mark>0</mark> 3	Air	4.	-13.9	27.5
_4	n	N ₂	1	- 421	836.)
**	n	N ₂	4	-12.2	24.0
Fine	AP//.120g	_	1	-134.5	267.0
``	`#	Azr	4	~12.9	25.7
	•	n ₂	1	- 92	182.8
п	π	N ₂	4	-14.8	29.5
Medium		Air	1	-12.5	24.8
AlgOg	8	Air	4	-13.6	26.9
	•	Na	1	-83.9	166.7
••	*	Ng	4	~ 9.0	17.9

Quarterly Reports represent all runs made and is not to be considered the final answer in each case. Such data will be subject to further rechecking and consideration. In some cases it may be necessary, in light of new measurements, to alter, discard or modify some of these recorded values.

Jemes E. Lend, Project Supervisor